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Materials for Advanced Recuperators

A cooperative agreement program
Department of Energy
Solar Turbines Incorporated
Allegheny Ludlum

March 2002

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Program Goal

Assist turbine manufacturers to be better positioned to offer more durable, higher efficient turbine generators that produce power at a competitive rate and allowing greater market penetration.

The cleaner operating turbines will assist the US in meeting the country's environmental goals and the goals of the DER initiative.

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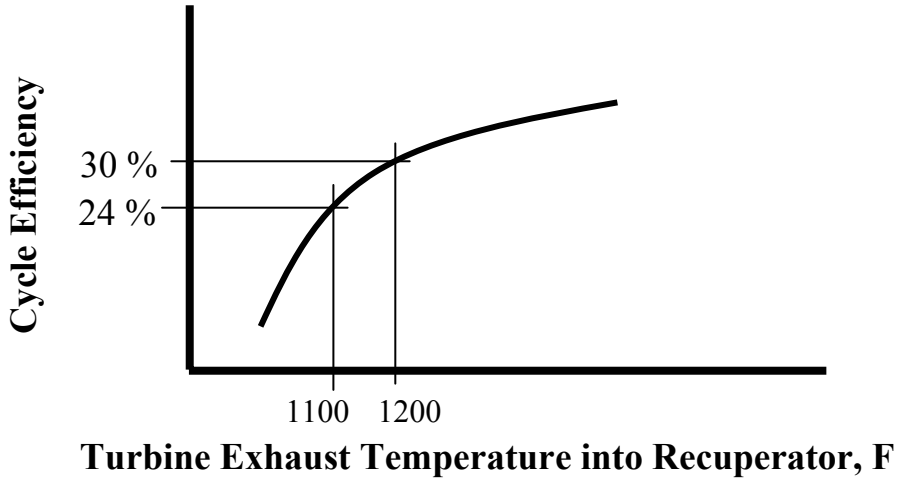
Current Status

Today's recuperator requirements are in need of higher performing, cost effective materials.

Recuperated turbine manufacturers would like to increase cycle efficiencies by increasing firing temperatures.

However, selection of affordable materials often restricts recuperator exhaust-side inlet temperature thereby restricting turbine-firing temperatures.



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Material Development

Options

Optimization of Existing Recuperator Foil Material

Develop/Optimize an Advanced Austenitic Foil

Identify & Employ a Nickel Base Foil Material

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Current Solar Experience

Thin Foil Material Capability (creep & oxidation)

Material	Upper Temp Operational Limit	Price Index
347 SS	< 1175 F	1X
A-625	<1300 F*	4X
H-230	<1300 F*	7X

* *Being verified in tests as part of this program*

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Current Solar Experience

Thin Foil Material Capability (creep & oxidation)

Material	Upper Temp Operational Limit	Price Index
347 SS	< 1175 F	1X
Adv Austenitic	1250 F	1.4 X
A-625	<1300 F*	4X
H-230	<1300 F*	7X

* *Being verified in tests as part of this program*

Material Development

Development Approach

Optimization of Existing Recuperator Foil Material

Increase the creep strength of 347 SS through management of manufacturing processes, and coat material after recuperator manufacturing to increase oxidation capability

Develop / Optimize an Advanced Austenitic Foil

Develop a higher temperature advanced austenitic foil with less than 1.4 X cost of 347 SS and a 1250 F capability

Identify & Employ a Nickel base Foil material

Increase the thin foil data base for Ni alloys to allow design engineers to more effectively use the higher cost materials

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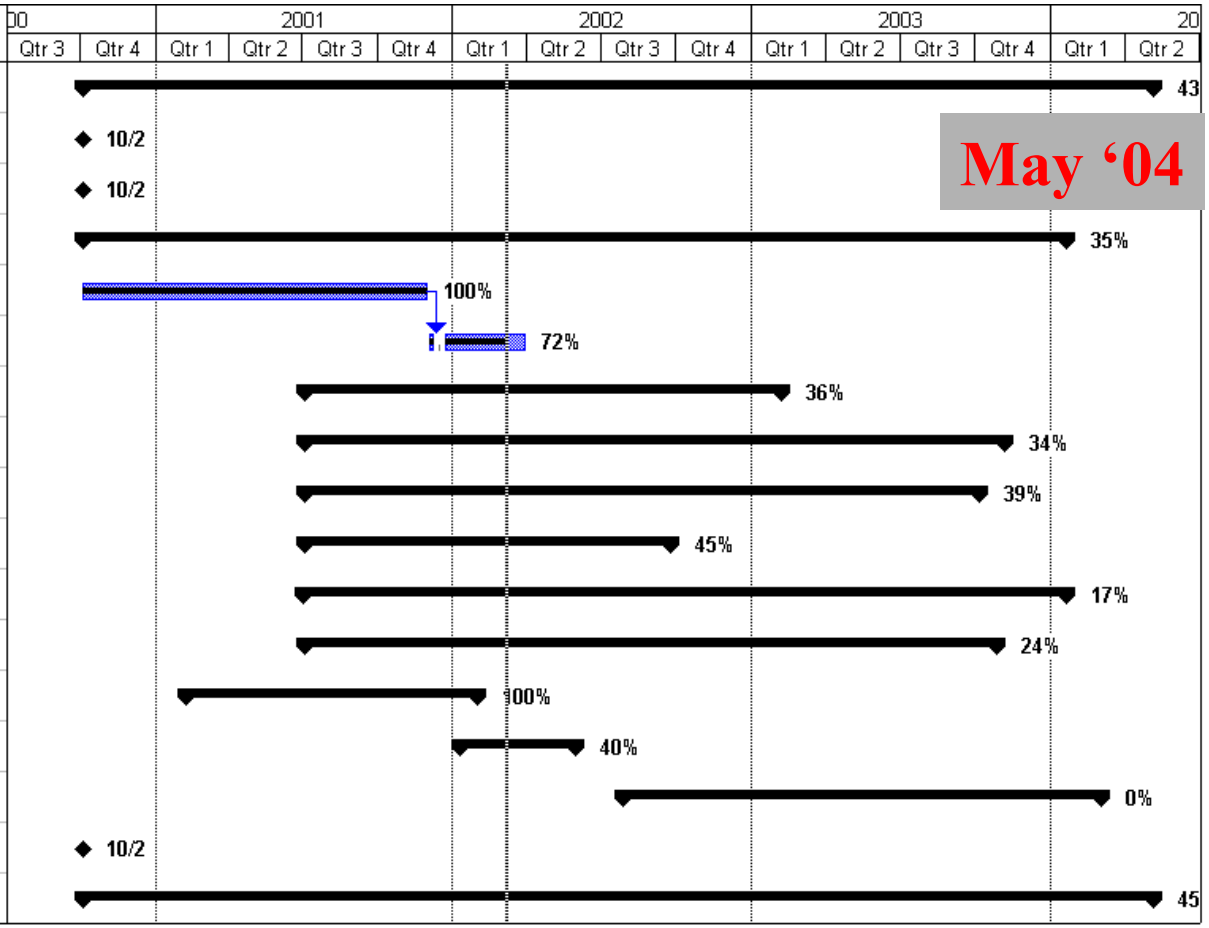
Overall Program Schedule

ID	WBS	Task Name
1	661947	Adv Recuperator Materials Developmen
2	1.1	Program Start
3	1.2	Open task number
4	1.3	Recuperator Alloy Development
5	1.3.0.1	Study - Existing Material Data
6	1.3.0.1.1	Report, Existing Material Data
7	1.3.1	Coated Type 347 Foil
17	1.3.2	Creep Resistant Type 347 Foil
38	1.3.3	Adv Austenitic Foil
64	1.3.4	Coated Adv Austenitic Foil
75	1.3.5	Dual Alloy Foil
97	1.3.6	Super Alloy Foil
119	1.4	Tasks redirected &/or stopped
159	1.5	Cost Evaluation
162	1.6	Recuperator Endurance Testing
169	1.7	Open task number
170	1.8	Program Management



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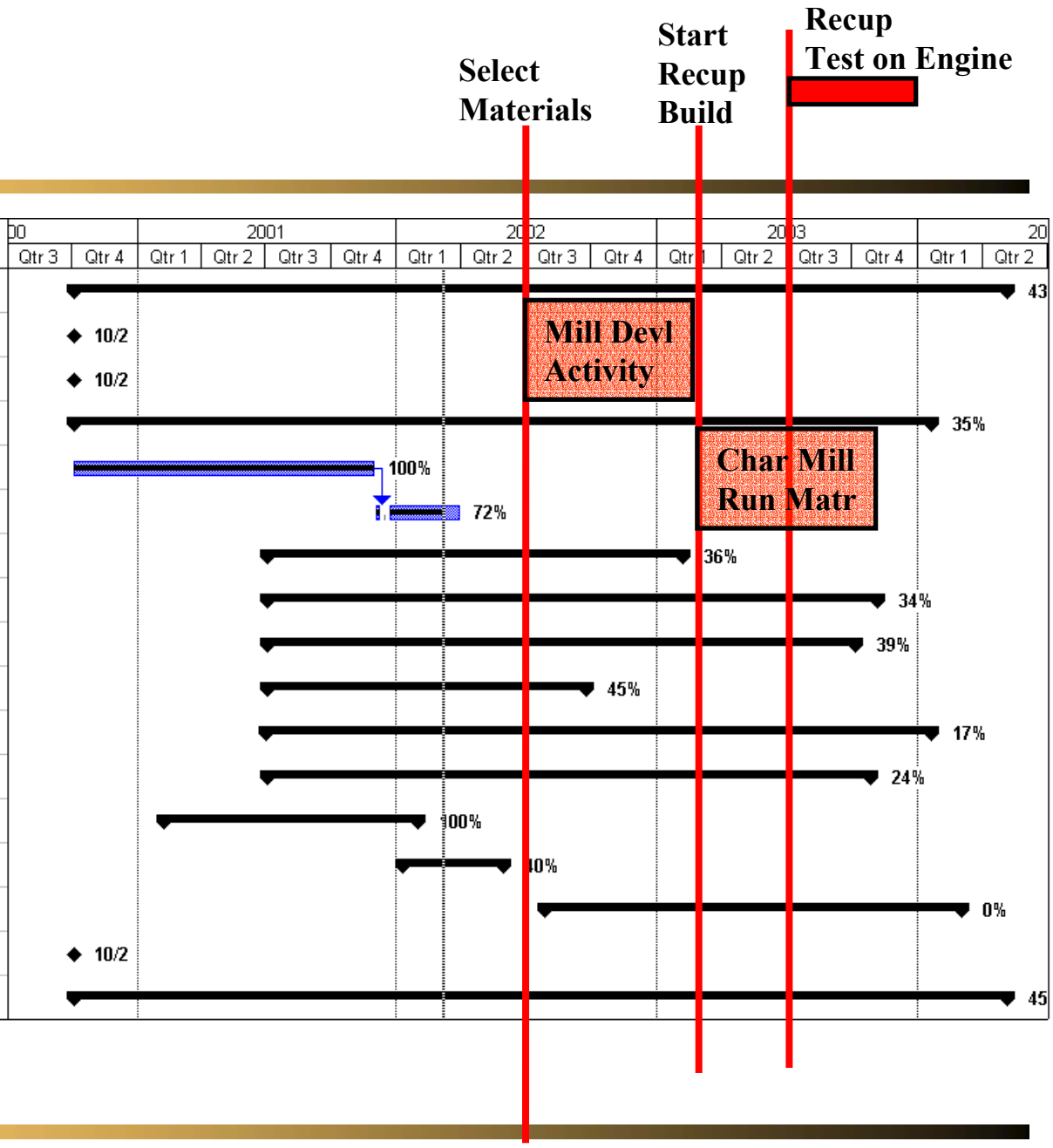

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Material Development

Material Properties - Primary Factors

- Oxidation Resistance
- Creep Strength
- Foldability/Formability
- Weldability

Material Development

Materials Development Approach

- Characterize Current Material Properties
- Determine Method to Optimize Properties
- Produce Lab Heat of Material
- Characterize Lab Heat Properties
- Transfer Production Techniques to the Mill
- Produce Mill Heat of Material
- Characterize Mill Heat Properties
- Fabricate Recuperator
- Test Recuperator in Turbine
- Evaluate Materials After Tests

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2001 Activities & Current Status

Coated Type 347 SS Foil:

- Meetings with potential suppliers have been concluded.
- Potential-coating processes evaluated.
- Coated test specimens have been prepared, tests started

Creep Resistant Type 347 SS Foil:

- Three heats of material have been made
- Materials have been rolled down to thickness
- Creep and oxidation tests are underway.

Advanced Austenitic Foil:

- Three heats of material have been made and processed
- Chemistry and microstructure checked. Both good.
- Oxidation tests completed; Creep tests underway.

Nickel Based Foil Materials

- Materials selected
- Lab size heats have been produced
- Creep test results are being evaluated
- Oxidation tests started

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Upcoming Milestones

Complete initial tests for material selection	**June 2002**
Materials selection for recuperator endurance test	**July 2002**
Start of recuperator endurance test	**June 2003**
Recuperator materials performance evaluation report	**January 2004**
Project complete	**April 2004**

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If an advanced austenitic alloy proves to be a viable recuperator material, Allegheny plans to commercialize the new material making it available to all that wish to purchase the material.

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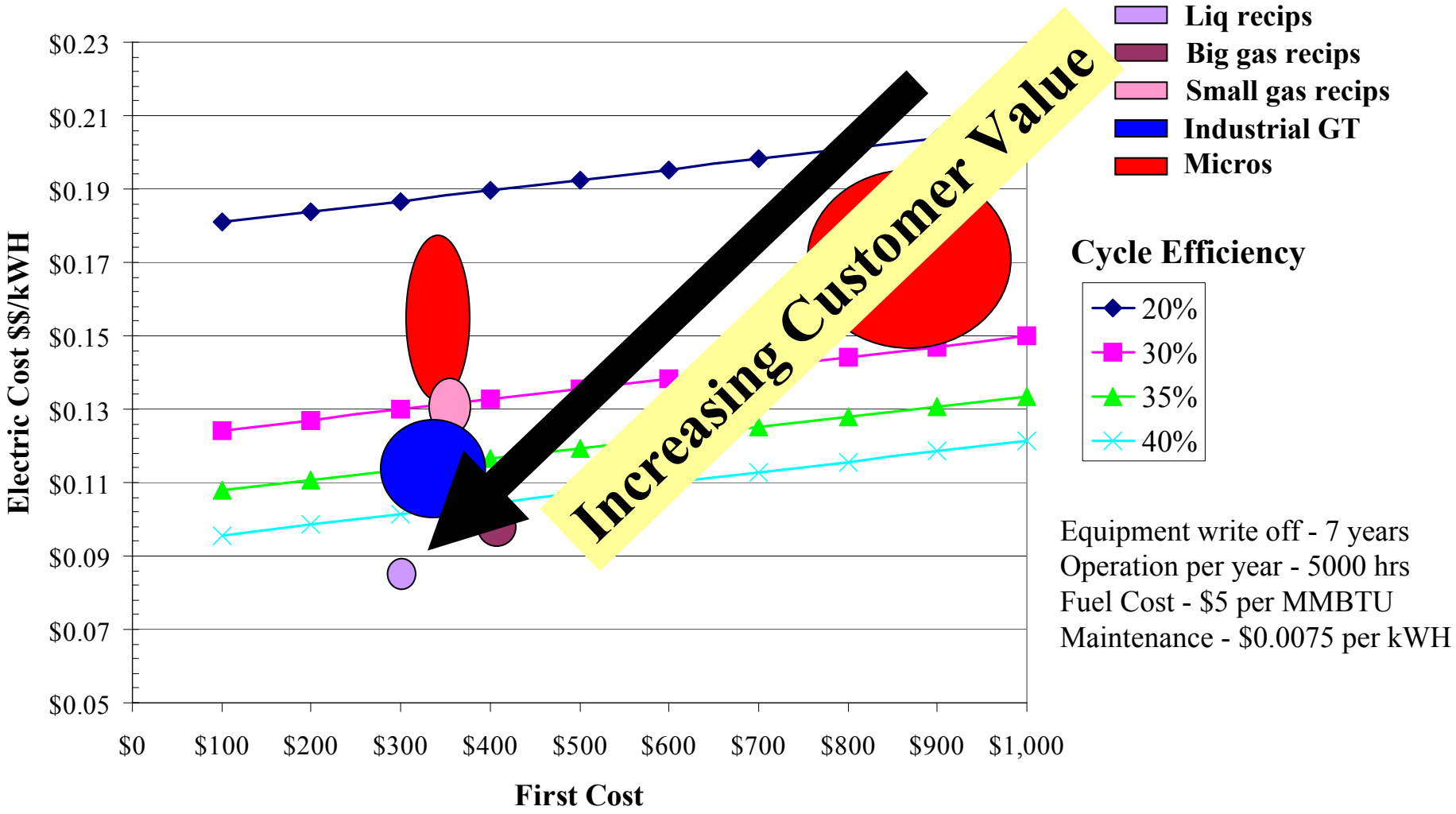
Comparison between Alternative Technologies



Equipment write off - 7 years
Operation per year - 5000 hrs
Fuel Cost - $5 per MMBTU
Maintenance - $0.0075 per kWH

Questions